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December 1974

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Abstract

The inferred polarity (towards or away from the sun) of the interplanetary magnetic field at earth using polar observations of the geomagnetic field has been compared with spacecraft observations. A list published by Svalgaard of the inferred field polarities during 1970 through 1972 is found to be correct on 84 per cent of the days. A near real time (same day) method of inferring the polarity of the interplanetary magnetic field using geomagnetic observations at Vostok and Thule is in use at the NOAA Space Environment Laboratory, Boulder, Colorado. During 1972 this method is found to be correct on 89 per cent of the days. A list of "well-defined" sector boundaries at earth during 1970 through 1972 is given.

COMPARISON OF INFERRED AND OBSERVED
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A method for inferring the polarity (towards or away from the sun) of the interplanetary magnetic field at earth has been discovered by Svalgaard (1968) and Mansurov (1969). This method uses observations of the geomagnetic field obtained at polar observatories such as Thule and Vostok, and has been described by Svalgaard (1972, see also Wilcox 1972). A list obtained with this method of the polarity of the interplanetary magnetic field at earth for each day in the interval 1970 through 1972 has been published by Svalgaard (1973). In this note, we compare the previously published inferred field polarities with observations obtained with spacecraft orbiting the earth. These observations have only recently become available.

Figure 1 shows a comparison of the inferred and observed field polarities during 1970. We note that the two sets of observations agree rather well, and that the large-scale sector structure can clearly be seen in both sets of observations. Figures 2 and 3 show the same information as Figure 1 for the years 1971 and 1972.

We may make a quantitative comparison of the inferred and observed field polarities during the years 1970 through 1972. Table 1 shows the number of days corresponding to each of the nine possibilities, i.e. the spacecraft may observe toward, away or mixed (tabulated horizontally), and the inferred field may be toward, away or mixed (tabulated vertically). Of the total of 664 days on which comparison of away or toward is possible, the agreement is 84 per cent and the disagreement is 16 per cent.

The amplitude of the daily variations in the polar geomagnetic field is considerably larger in summer than in winter. It is therefore possible to infer the interplanetary field polarity somewhat more accurately in summer than in winter. In order to investigate this difference quantitatively we have prepared Tables 2 and 3 that are in the same format as Table 1, except that Table 2 includes the six months centered about summer in 1970 through 1972, and Table 3 includes the six months centered about winter in these years. Of the 298 days in which comparison between away and toward is possible during the summer the agreement is 90 per cent and the disagreement is 10 percent. Of the 366 days on which comparison of toward and away is possible during winter the agreement is 80 per cent and the disagreement is 20 per cent.

A previous series of papers (Wilcox and Colburn, 1969, 1970, 1972) has given lists of the times of observation at earth of "well-defined" sector boundaries. These lists were based only on spacecraft observations, and usually defined the time of the boundary observation to within a three-hour interval. For the purpose of continuing this list during the years 1970 through 1972 the situation is somewhat different. There are considerable gaps in the spacecraft observations, as can be seen from Figures 1 - 3. However, the inferred polarity of the interplanetary field is now available in a rather reliable manner, as has been discussed above. If a list of well-defined sector boundaries were to be prepared using the exact criteria used by Wilcox and Colburn (1969, 1970, 1972) there would be rather few entries on the list because of the large number of gaps in the spacecraft observations. Instead, one of us (LS) has prepared a list of well-defined boundaries using both the observed and the inferred field polarities as shown in Figures 1-3. The criteria for determining well-defined boundaries are analogous to those used earlier, i.e. that in the best judgement of the investigator, using the inferred and observed field polarities, there were at least four days with one field polarity followed by at least four days of the opposite field polarity. The time of the polarity is defined on a daily (24 hour) interval rather than on the three hour intervals used previously. This list of well-defined boundaries is given in Table 4, where the first

day of the new sector as observed at earth is tabulated.

The average change of the geomagnetic activity index Kp at a sector boundary during the years 1970 thru 1972 has been investigated using the boundaries tabulated in Table 4 in a superposed epoch analysis. The result is shown in Figure 4. The average response of Kp near a sector boundary as shown in Figure 4 is very similar to the result found in several previous years by Wilcox and Colburn (1968,1970,1972). This suggests that the form of the response of geomagnetic activity as a sector boundary is carried past the earth by the solar wind remained rather constant during most of the present sunspot cycle. We may also conclude that the list of well-defined sector boundaries prepared as described above and tabulated in Table 4 is not noticeably inferior for this kind of analysis to the methods previously employed.

S.M. Mansurov, Robert Doeker, Gary Heckman and two of the present authors (JW and LS) have established a system of inferring the polarity of the interplanetary magnetic field in near real time (same day). Hourly average values of the geomagnetic field components are sent by radio from the USSR station at Vostok (in the southern polar region) to the Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation near Moscow, and thence by teletype to the NOAA Space Environment Laboratory in Boulder, Colorado. Similar hourly averages of the geomagnetic field components observed with a tri-axis magnetometer located at the Thule Geopole Station of the Air Weather Service are also sent by teletype to Boulder. (See descriptive text in Solar Geophysical Data 1973).

Now that spacecraft observations of the polarity of the interplanetary magnetic field during 1972 are available, it is possible to evaluate the quality of the method used in Boulder. Figure 5 shows a comparison of the interplanetary field polarity inferred in Boulder with the polarity observed with spacecraft magnetometers during 1972. Figure 5 is in the same format as Figure 1. The top line of each pair represents the field observed by spacecraft orbiting the earth, and the bottom line of each pair represents the field polarity inferred in near

real time in Boulder. Table 5 shows a quantitative comparison of the inferred and observed field polarities in the same format as Table 1. Of the total of 225 days on which comparison of away or toward is possible, the agreement is 89 per cent and the disagreement is 11 per cent (spacecraft observations were missing on 83 days during 1972). We thus conclude that the method for inferring the polarity of the interplanetary magnetic field used in Boulder on the basis of geomagnetic observations from Vostok and Thule gave the correct polarity during 89 per cent of the days in 1972.

Acknowledgements

Spacecraft magnetometer observations of the interplanetary magnetic field used in this work were obtained from the Ames Research Center experiments on Explorers 33 and 35 by courtesy of David Colburn, and from the Imperial College of Science and Technology experiment on spacecraft HEOS 1 and 2.

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Figure Captions

Fig. 1. Comparison of the observed and inferred interplanetary magnetic field polarities during 1970. Bartels rotation numbers are given on the right and the starting day of each rotation is indicated on the left. The top line of each pair represents the field observed by spacecraft orbiting the earth, and the bottom line of each pair represents the inferred field polarity published by Svalgaard (1973). A small dot represents a day with field polarity directed away from the sun, a large dot represents a day with field polarity directed toward the sun, an x represents an uncertain or ambiguous day, and a blank represents a gap in the spacecraft observations.

Fig. 2. Same format as Figure 1, but for 1971.

Fig. 3. Same format as Figure 1, but for 1972.

Fig. 4. The average change in the geomagnetic activity index Kp near sector boundaries. The figure shows a superposed epoch analysis based on the 95 boundaries listed in Table 4.

Fig. 5. Same format as Figure 1, but comparing the interplanetary field polarity inferred at the NOAA Space Environment Laboratory, Boulder, Colorado, (see text) with spacecraft observations. The Boulder data is tabulated in Solar Geophysical Data (1974).

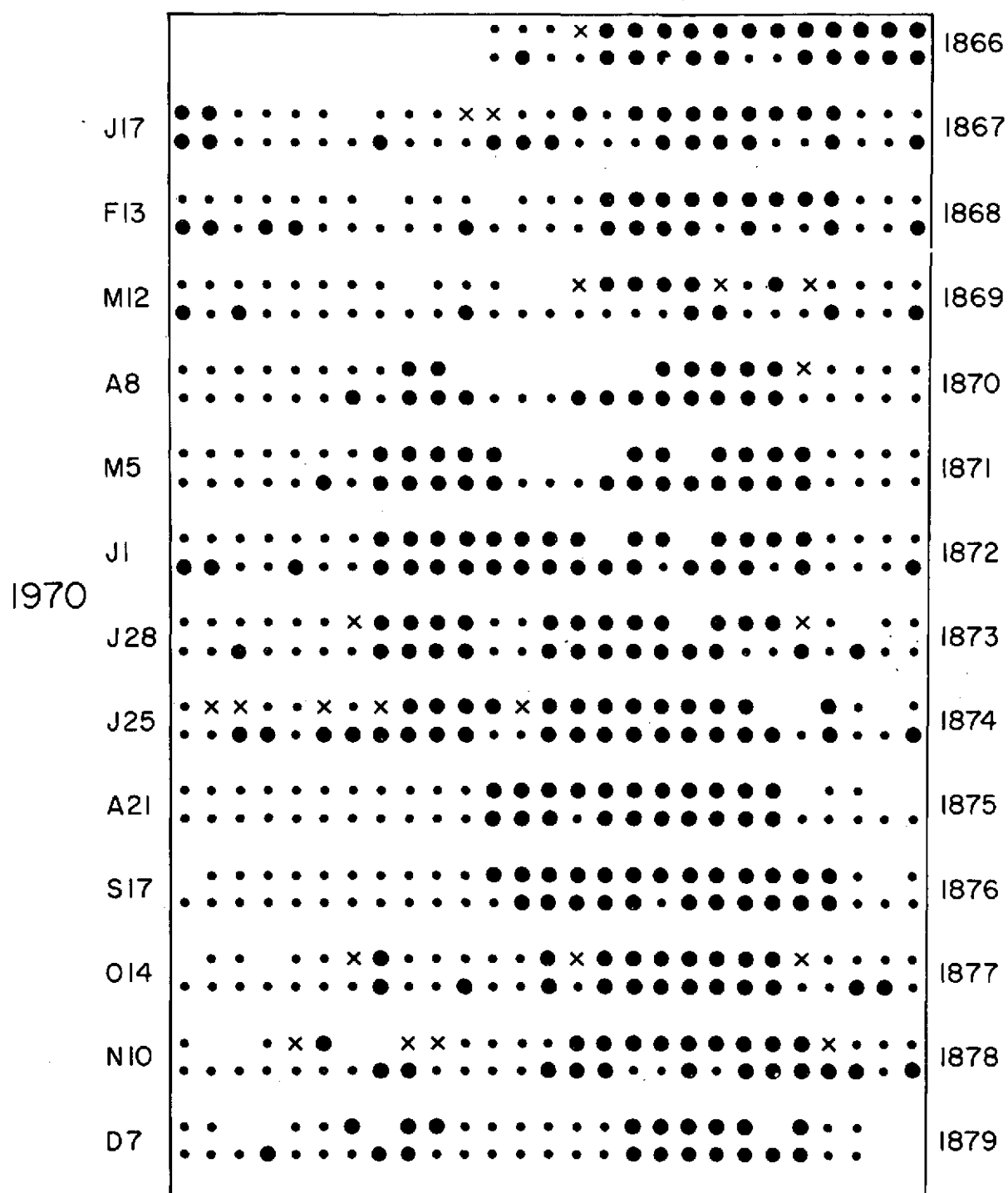


Figure 1

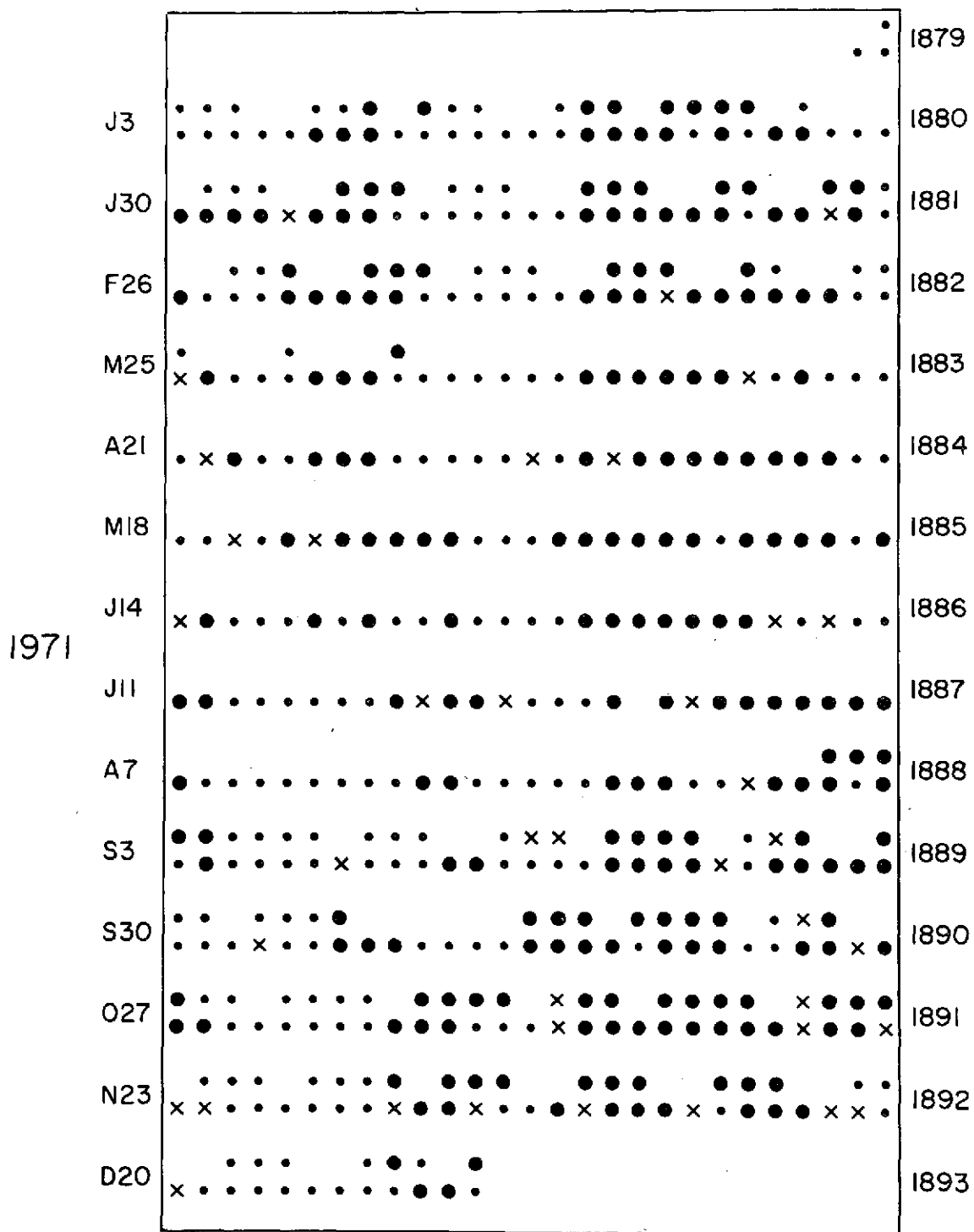


Figure 2

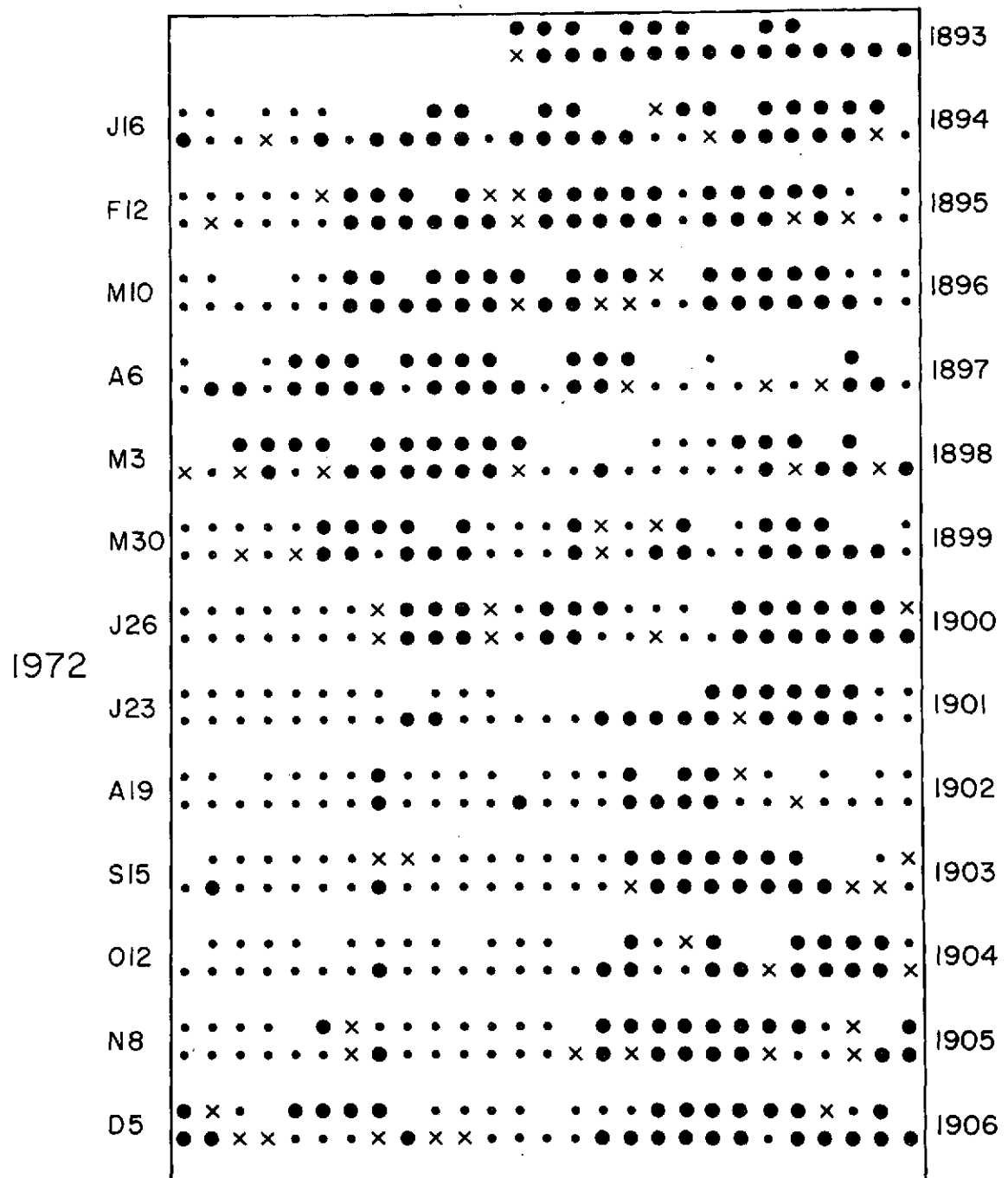


Figure 3

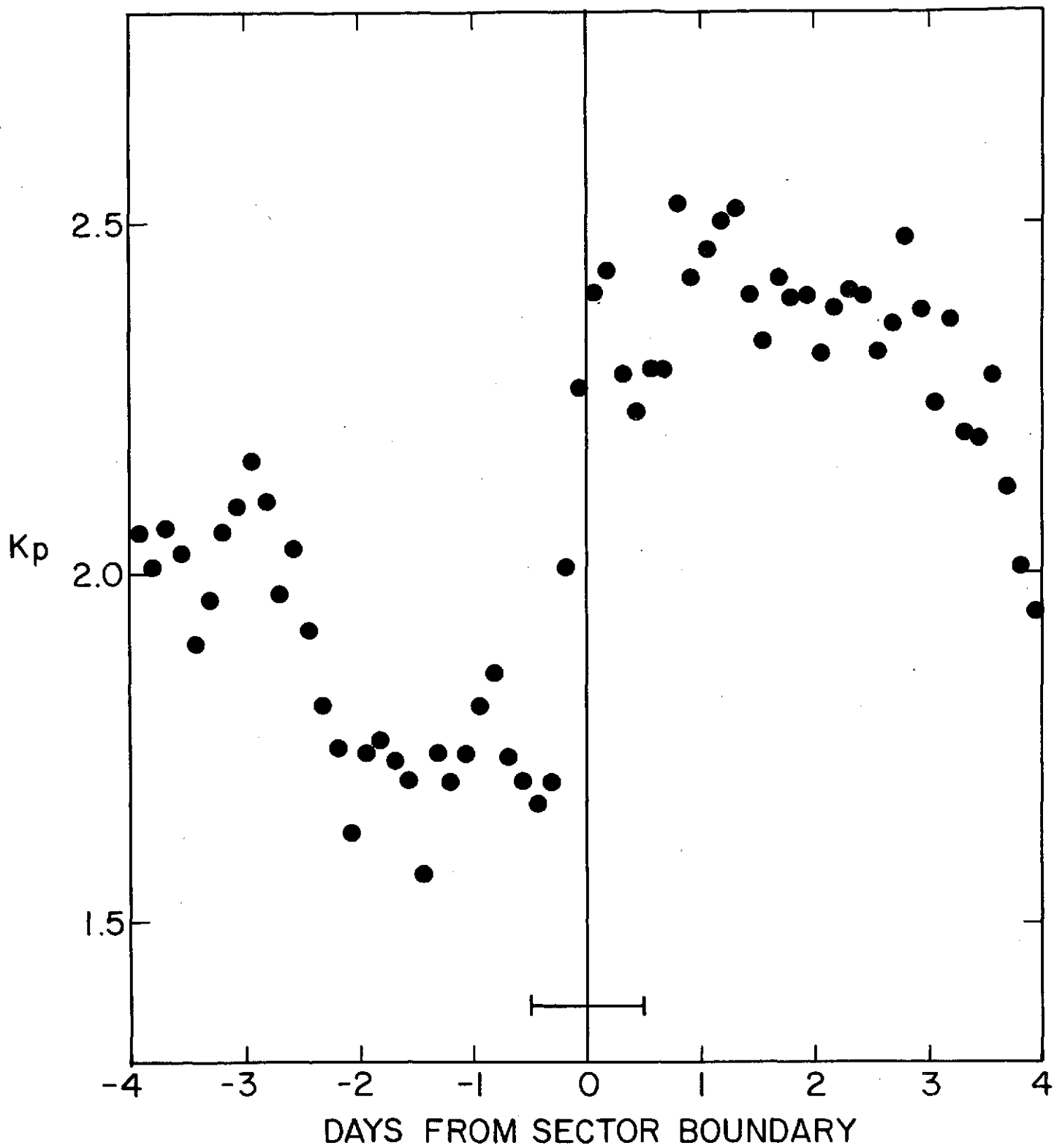


Figure 4

TABLE 1. Daily Comparisons of Inferred and Observed Polarities of the Interplanetary Magnetic Field During 1970 Through 1972.

		<u>Observed</u>		
		Toward	Away	Mixed
<u>Inferred</u>	Toward	280	50	15
	Away	54	280	22
	Mixed	24	15	8

TABLE 2. Daily Comparisons of Inferred and Observed Polarities of the Interplanetary Magnetic Field During the Summers of 1970 Through 1972.

		<u>Observed</u>		
		Toward	Away	Mixed
<u>Inferred</u>	Toward	121	15	7
	Away	16	146	9
	Mixed	6	3	3

TABLE 3. Daily Comparisons of Inferred and Observed Polarities of the Interplanetary Magnetic Field During the Winters of 1970 Through 1972.

		<u>Observed</u>		
		Toward	Away	Mixed
<u>Inferred</u>	Toward	159	35	8
	Away	38	134	13
	Mixed	18	12	5

TABLE 4. Times at Which Well-Defined Sector Boundaries Passed the Earth During 1970 - 1972. The First Day of the New Sector is Listed.

Toward to Away Boundaries

19	January	1970
10	February	1970
9	March	1970
4	April	1970
30	April	1970
28	May	1970
24	June	1970
21	July	1970
16	August	1970
12	September	1970
11	October	1970
5	November	1970
4	December	1970
30	December	1970
11	January	1971
26	January	1971
8	February	1971
25	February	1971
8	March	1971
23	March	1971
3	April	1971
18	April	1971
16	May	1971
29	May	1971
12	June	1971
9	July	1971
8	August	1971
5	September	1971
30	September	1971
28	October	1971
23	November	1971
17	December	1971
16	January	1972
11	February	1972
7	March	1972
3	April	1972
1	May	1972
16	May	1972
28	May	1972
10	June	1972
25	June	1972
23	July	1972
17	August	1972
8	September	1972
10	October	1972
7	November	1972
13	December	1972

Away to Toward Boundaries

4	January	1970
31	January	1970
28	February	1970
27	March	1970
22	April	1970
12	May	1970
8	June	1970
5	July	1970
1	August	1970
1	September	1970
28	September	1970
27	October	1970
24	November	1970
23	December	1970
7	January	1971
18	January	1971
3	February	1971
14	February	1971
2	March	1971
13	March	1971
30	March	1971
9	April	1971
6	May	1971
22	May	1971
1	June	1971
29	June	1971
27	July	1971
23	August	1971
19	September	1971
13	October	1971
4	November	1971
1	December	1971
28	December	1971
23	January	1972
18	February	1972
16	March	1972
10	April	1972
5	May	1972
23	May	1972
4	June	1972
3	July	1972
16	July	1972
6	August	1972
4	September	1972
1	October	1972
27	October	1972
23	November	1972
21	December	1972

TABLE 5. Daily Comparisons of Inferred and Observed Polarities of the Interplanetary Magnetic Field During 1972 Using the Field Polarities Inferred at the NOAA Space Environment Laboratory in Boulder.

		<u>Observed</u>		
		Toward	Away	Mixed
<u>Inferred</u>	Toward	98	10	18
	Away	15	102	22
	Mixed	7	6	6